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Matching social-ecological systems by understanding the spatial scale of environmental attitudes

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Abstract

Mismatching in the spatial scales of social structures and ecological processes complicates the management of natural resources. Here we suggest the use of variance components to determine at which spatial scale variation in feelings, environmental attitudes and value orientation is largest and hence most exposed to conflicts. We estimated the variance components of the feeling of fear for large carnivores, environmental attitudes towards large carnivores and environmental value orientation at 3 scales (municipality, county and country) in Norway and Sweden. The feeling of fear for specific carnivores had the highest variance components at the municipality level, we found no specific scale that best explained the variance in attitudes towards carnivores in general, while attitudes based on environmental value orientation showed the highest variance components at the country level. To match the social-ecological systems, we conclude that management units have to be designed as the best possible trade-off between the social and ecological scales; i.e. largest possible to maintain ecological sustainability, but small enough to maintain a low degree of social conflicts.

Keywords

carnivores, conflict, human-wildlife, management, scale, variance components

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Introduction

Scaling is an important issue in ecology as patterns and processes vary with scale. The most appropriate scale to study will depend on the species', or the individuals', perception of the landscape and the organisational level of interest. For instance, individuals, populations, ecological communities, ecosystems and landscapes will require different scales of the study (e.g. Wiens 1989, Gaillard et al. 2010). Scaling in the social sciences relates to individuals and social structures that govern jurisdictions, laws, policies, cultural norms and values, resource access rights, economics and management responsibilities (e.g. Gibson et al. 2000, Cumming et al. 2006). Most often, such structures have a spatial dimension and Gibson et al. (2000) defined the following spatial levels of political jurisdictions: household, community, regional, national and international. The different nature of social science and ecology makes it difficult to create common definitions or comparisons of scale (Gibson et al. 2000) resulting in the management of natural resources is functioning at a different scale than the ecological processes subjected to management interventions (Norton 1998, Cumming et al. 2006).

Ideally, management units should incorporate large enough areas to ensure sustainability of the ecological process, but, at the same time, avoid incorporating excessive attitudinal variation in order to avoid problems that are outside the powers of managers. This connection between the ecological and social scale is important as management policies are dynamic and to a large extent founded on public opinion (Butler et al. 2003). Management may thus make decisions at a scale that fits the public opinion, but not necessarily the ecological sustainability. In wildlife management, anything connected to public opinion is often labelled as attitudes and are most frequently studied using social-psychological approaches in which attitudes are thought to be psychological characteristics of individuals (Manfredo and Dayer 2004, Peterson et al. 2010). In scientific terms, attitudes may be defined as people's evaluation of their surroundings referring to an object, issue or an event (Eagly and Chaiken 2007, Manfredo 2008) and is a complex, but precise construct, made up of cognitive, emotional and behavioural components (Stern et al. 1995). Attitudes are assumed to be rather stable as the complex structures are difficult to break apart (Heberlein 2012).

Attitudes are part of the cognitive hierarchy together with norms and values (Manfredo and Dayer 2004). The complex structures of the cognitive hierarchy consist of an array of components that show different origin and stability. For instance, values are fundamental, achieved early in life and highly resistant to change (Bjerke and Kaltenborn 1999, Manfredo and Dayer 2004). In wildlife management, the value concept is often described as environmental value orientation ranging from ecocentric values (wildlife protection) to anthropocentric values (wildlife use) (Thompson and Barton 1994, Bjerke and Kaltenborn 1999). We therefore assume that environmental value orientation is an even more stable component than attitudes. On the other hand, attitudes consist of an emotional component which is more volatile (Scherer 2005). Emotions are also described as complex structures, amongst others, consisting of feelings which have a cognitive input and are the subjective mental associations to an emotion (Damasio 2000, Scherer 2005).

To approach a common social-ecological understanding of scale, we have taken some of the social responses connected to components of the cognitive hierarchy (i.e. feelings, attitudes and environmental value orientation) and analysed them in a typical physical way by using variance components to reveal at which spatial scale variability is being introduced to these components. We have based our analyses on the results from a questionnaire related to large carnivores. Large carnivores present a good opportunity for studying social-ecological scales since public opinion affects policy at multiple levels. The presence of carnivores changes locally, human-carnivore conflicts change locally and the management of carnivores changes from national authorities to more regional or local authorities and may also change over time (Bisi et al. 2007, Majic et al. 2011, Treves et al. 2013).

We assumed that the relatively stable components of the cognitive hierarchy develop slowly over time and expand into larger stable socio-spatial structures, e.g. at a regional or national level, rather than changing abruptly depending on changes in the local environment. Hence, we expected that feelings (here represented by fear towards specific carnivore species) were connected to local changes in the presence of the carnivore species and thus to have the highest variation at local scales (i.e. municipality). Furthermore, we expected attitudes towards carnivores to have the highest variation at an intermediate scale (i.e. county) and environmental value orientation to have the highest variation at a large scale (i.e. country).

Methods

Data on attitudes were collected in 2011 through a telephone survey carried out by a data collection company (www.norstat.no) from 4–5 respondents in each municipality in Norway and Sweden. The data collection company (NORSTAT) bases its sample on existing registers that are publicly available when they collect data by telephone interviews. When the respondents in our study were contacted, the interviewer followed a strict protocol as dictated by standard research ethics, including presenting the purpose of the study and the agency behind it, that participation is entirely voluntary, how long the interview would take and how the results would be used (see Gangaas et al. 2013 for a more detailed description of the questionnaire).

The survey provided answers from 2522 respondents (1508 in Norway and 1014 in Sweden) from 722 municipalities, which are combined into 40 counties from 2 countries (Norway and Sweden; Table 1). The sample was designed not to be representative of the population in the two countries, but to detect spatial patterns and facilitate analysis of differences between local, regional and national levels (Fig. 1).

The large carnivores in Norway and Sweden consist of brown bear *Ursus arctos*, wolverine *Gulo gulo*, lynx *Lynx lynx* and wolves *Canis lupus*. These large carnivores are managed at the national scale in both Norway and Sweden, while some of the management actions are delegated down to a local scale (county level or to local boards consisting of politicians from counties merged into specific management regions). There are differ-

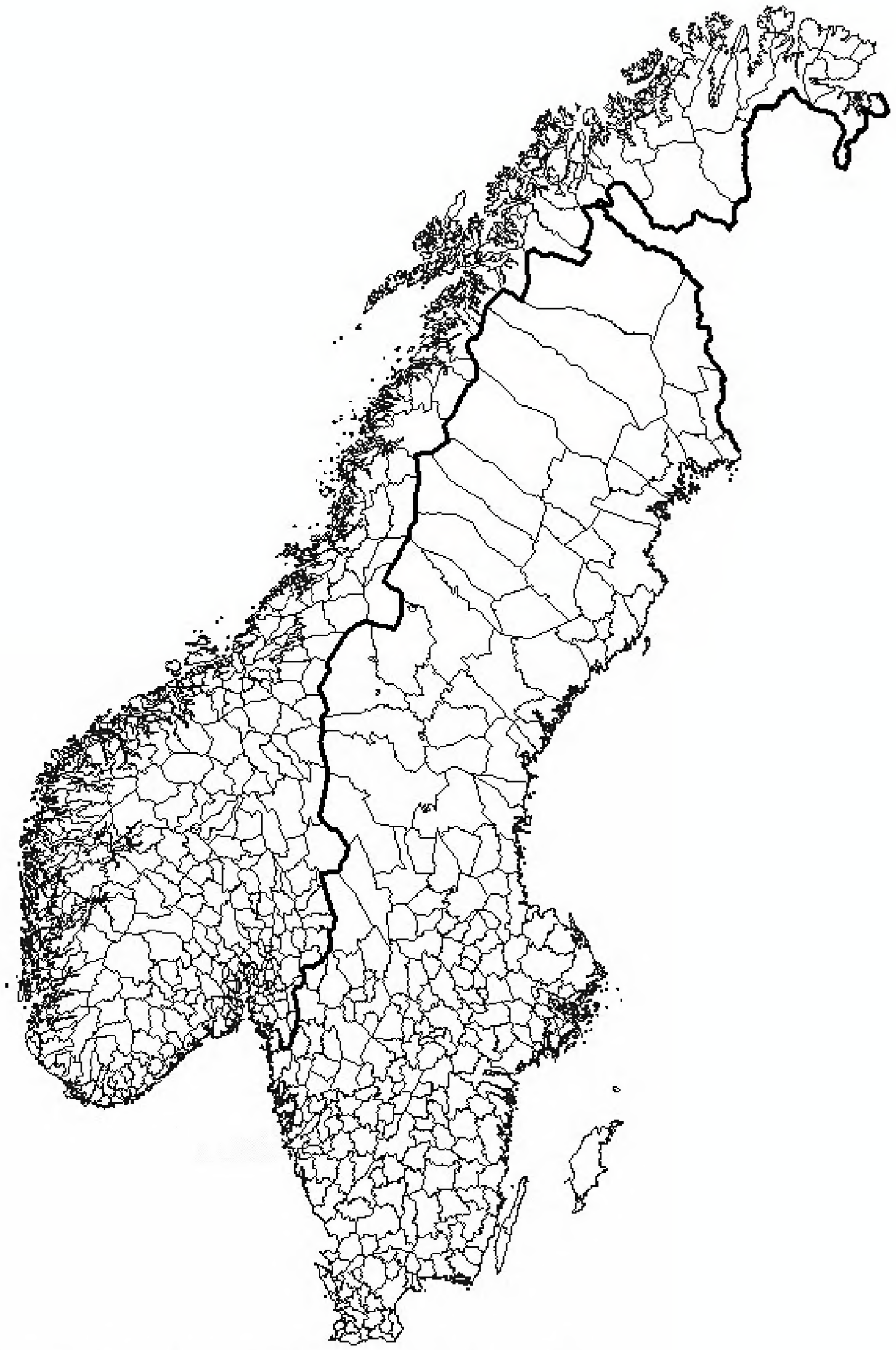

Figure 1. Map of Norway and Sweden split into the 722 municipalities.

Table 1. The number of municipalities, counties and countries analysed to describe the local, regional and national levels.

Level	Norway	Sweden
Municipality	431	291
County	19	21
Country	1	1

ences in the numbers of carnivores between the two countries, as Sweden houses much higher densities of all large carnivore species compared to Norway (Linnell et al. 2000).

The full questionnaire included questions characterising the respondent (e.g. sex and age), several questions that were given only to some respondents depending on whether their acceptance of carnivores was unconditional or not and questions related to management and expressions used to identify the respondents' general environmental attitudes (Gangaas et al. 2013). Here we analysed questions and statements that were asked of all respondents and that were not directly connected to management (Table 2). These questions and statements were answered with a 3 to 5-level scale as described in Table 2. Note that the direction of the answer (i.e. towards an anthropocentric or an ecocentric view) is not important in the present context as our focus is on the variance of the answers.

We expected that the presence of carnivores could cause local conflicts that could change humans' attitudes towards carnivores at a local scale and even more if the carnivore species were emphasised by species names. We classified *a priori* the following spatial scale expected to give highest variance for the given feeling/attitude stated in the questions and expressions:

- Small (i.e. municipality) scale to questions and expressions describing feelings or attitudes towards specific carnivore species
- Intermediate (i.e. county) scale to questions and expressions describing attitudes towards carnivores in general, without naming the carnivore species
- Large (i.e. country) scale to questions and expressions describing environmental value orientation.

All questions and the scale expected to have the highest variation are listed in Table 2. All analyses were done with the lme-function in R 3.0.1 (http://cran.r-project.org/) by extracting the variance components from random nested models (Country/County/Municipality) with the varcomp-function. We then estimated the percentage of each of the spatial scale component contributed to the random variance components.

Results

Our results did, to some extent, confirm our predictions. The very specific questions related to fear of specific carnivore species had largest variance components at a small scale (S1 – S4; Figs 2, 3). However, the variance components with regard to the other

Table 2. The questions and statements from the questionnaire included in the analyses, with the scale we *a priori* expected would explain most of the variation (small is municipality, medium is county and large is country). We registered replies to questions S1 – S4 as 1: not at all, 2: a little scared, 3: quite scared and 4: very scared; M1 as 1: too few, 2: just the right amount and 3: too many. All other questions were registered as: 1: highly disagree, disagree, 3: neither agree nor disagree, 4: agree; 5: highly agree. Note that agreement to the questions M2, M4, L4 and L6 indicates the anthropocentric view, while questions M3, M5, M6, L1–L5 and L7 are reversed and disagreement also indicates the anthropocentric view.

ID*	Expected scale	Question / Statement
Questions related to emotions		
S1	Small	How scared are you of wolverine?
S2	Small	How scared are you of wolf?
S3	Small	How scared are you of brown bear?
S4	Small	How scared are you of lynx?
Questions related to attitudes		
S5	Small	Poaching of wolverine is acceptable
S6	Small	Poaching of wolf is acceptable
S7	Small	Poaching of brown bear is acceptable
S8	Small	Poaching of lynx is acceptable
M1	Medium	Do you think there are too few, just the right amount or too many large carnivores in your country today?
M2	Medium	Fear is a good enough reason to remove large carnivores
M3	Medium	Large carnivores are an enrichment for my nature experience
M4	Medium	Large carnivores limit my use of nature
M5	Medium	Seeing large carnivores in nature is a privilege
M6	Medium	Norway/Sweden is a rich country that should take responsibility for large carnivores
Questions related to value orientation		
L1	Large	Seeing tracks and signs increase my quality of life
L2	Large	The balance in nature is delicate and easily upset
L3	Large	Humans are severely abusing the environment
L4	Large	The so-called "ecological crisis" facing human kind has been greatly exaggerated
L5	Large	Plants and animals have the same rights to life on earth as humans
L6	Large	The balance of nature is sufficiently stable to withstand the impacts from a modern industrial society
L7	Large	If things continue on their present course, we will soon experience a major ecological catastrophe

* ID is an identification of the question used in Fig. 1.

4 questions related to attitudes to specific carnivore species (S5–S8; acceptance of illegal hunting) were highest at the large country scale. Questions related to carnivores in general, without naming the carnivore species, were not related to any specific scale as the variance component was more evenly distributed between municipality, county and country. The general questions, related to environmental value orientation had, as expected, the largest variance components at the largest scale (country).

Discussion

Attitudes toward the environment have frequently been studied with questionnaires at one given spatial scale, e.g. at a national or regional level (Bjerke et al. 1998, Kalten-

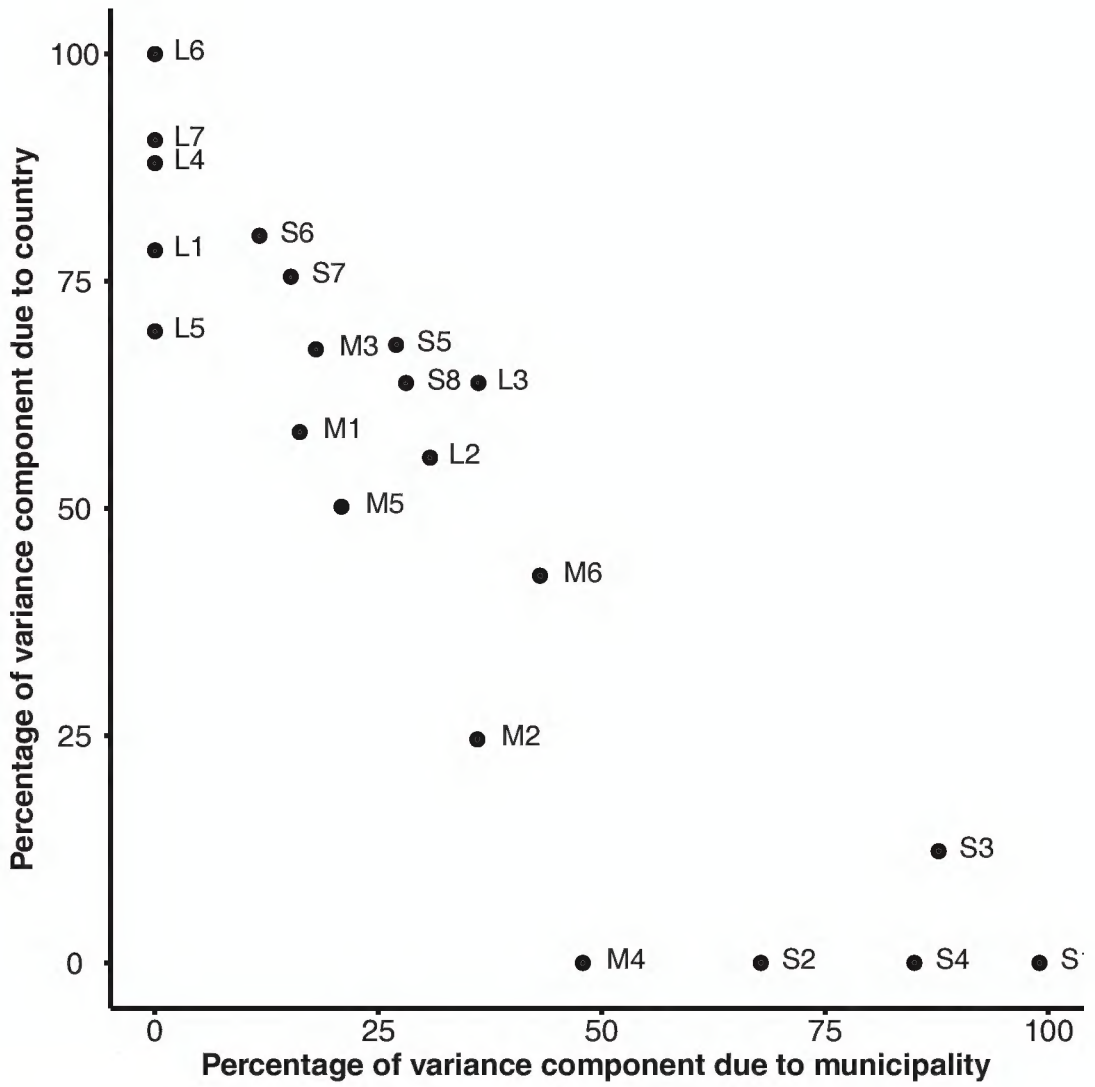

Figure 2. The location of the questions and statements (described in Table 2) depending on the percentage of the variance components explained by municipality (small scale) and country (large scale). Questions and statements located at the lower right of the plot are mainly explained by variations at smaller scales, while questions and statements at upper left of the plot are mainly explained by variation at larger scales.

born et al. 1998, Kaltenborn and Bjerke 2002, Butler et al. 2003, Roskaft et al. 2007, Heberlein and Ericsson 2008, Kaltenborn et al. 2008, Ardahan 2012, Heberlein 2012), while attitudinal variation in space has received less attention (Gangaas et al. 2013; 2014). Hence, even though the mismatch between social and ecological scale is evident, there have been few attempts to study at what spatial scale variation in feelings, attitudes and value orientation are introduced.

We need to understand the role of how attitudes are developed in conservation biology since attitudes heavily influence public opinion and policy-making (Manfredo et al. 1999). Even though measuring a subject's attitude from questionnaires does not imply that the respondent will behave in accordance with the attitudes expressed, attitudes explain a significant part of the variance in behaviour (Manfredo 2008, Heberlein 2012, Kaiser et al. 1999, Milfont and Duckitt 2010, Rodríguez-Barreiro et al. 2013, Armitage and Conner 2010, Rivis et al. 2009, Bamberg and Möser 2007)

Here, we broke down the variance in our responses from a broad spectrum of questions related to environmental feelings, attitudes and value orientation into various spatial scales. As expected, the variability in the responses depended on specific spatial scales. A large degree of the variation in fear for carnivores was connected to the

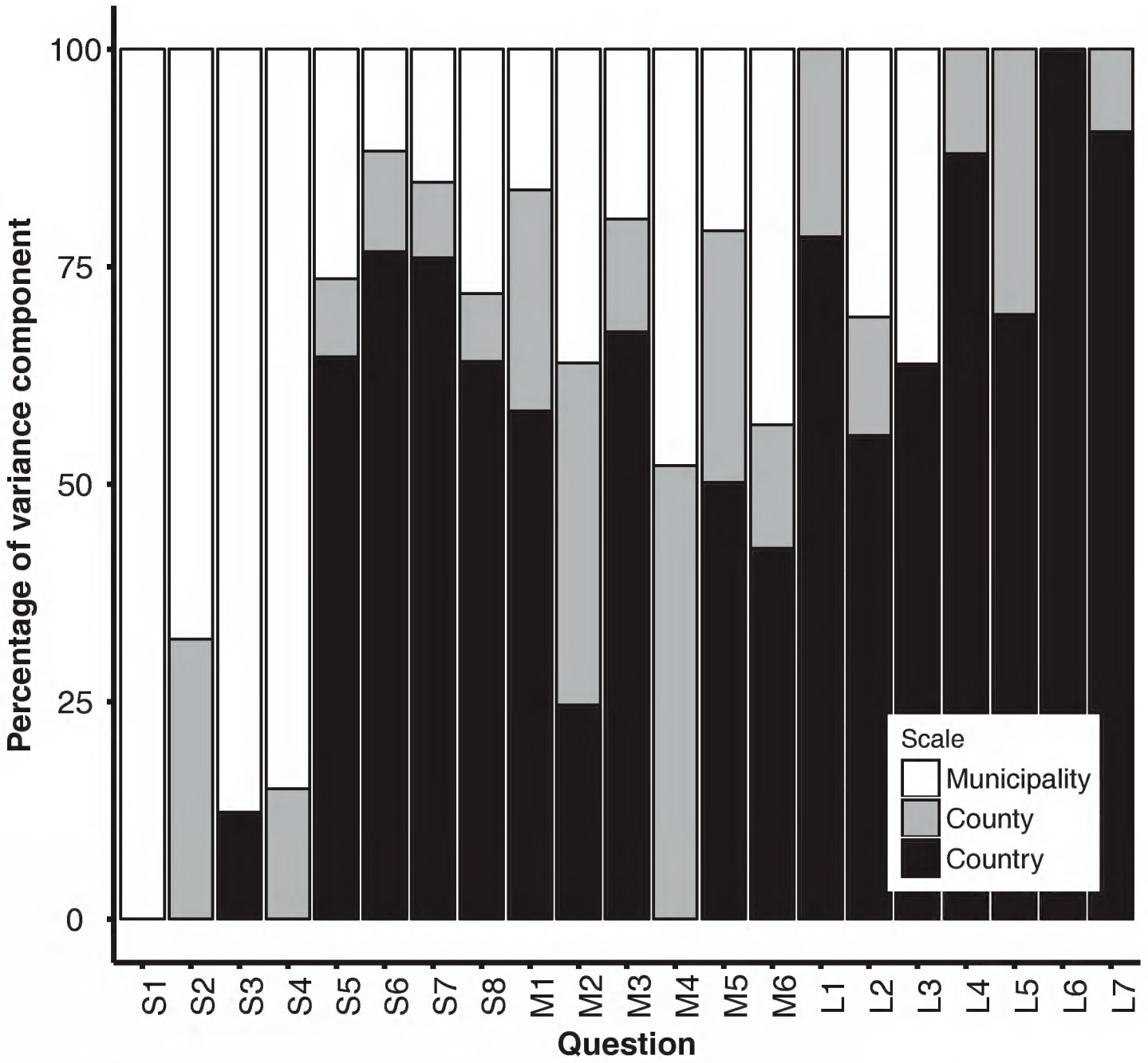

Figure 3. The percentage of the variance components explained by municipality (white), county (grey) and country (black) for each of the questions and statements in Table 2.

local scale. This connection appeared despite the low number of respondents per municipality. Contrary to our expectations, the variability in acceptance of illegal hunting of specific carnivore species was best described at the country level. General attitudes towards carnivores did not relate to any specific spatial scale, while most of the questions and expressions related to value orientation and environmental attitudes were best explained at the level of country as expected.

We argue that certain feelings or attitudes specifically related to carnivore species may be changeable and develop at local spatial scales, possibly as a result to environmental changes. For instance, Bisi et al. (2007) and Treves et al. (2013) showed that the fear of wolves decreased through time, but not the acceptance of wolves. Fear of animals represents complex emotional and somatic reactions to the experience of danger and is usually divided into a) expectations and beliefs about threats (cognition), b) physiological emergency reactions (somatic), c) feelings of dread or panic (emotion) and sometimes d) fleeing or fighting (behaviour) (Roskaft et al. 2003). Fear of large predators is usually

considered as a rational, natural and adaptive response, but can be difficult to predict or treat considering its complexity and fundamental importance to human psyche and development. It is also, to some extent, conditioned by exposure. The feeling of fear for carnivores may be developed in as small a scale as a household and spread into the local community, being accelerated as a response to the new perception of the environment.

We may expect that environmental attitudes responding to the large spatial scale have developed over time and there seem to be national socio-spatial structures that are difficult to change (see also Heberlein 2012). We have previously shown that the presence of carnivores today or in historic times did not correlate with acceptance of illegal hunting or general environmental attitudes, but differs between countries (Gangaas et al. 2013). Consequently, these attitudes are not affected by local changes in the environment, for instance recolonising carnivores, at least not in a short to moderate time span. Despite Norway and Sweden sharing many national level policies, economies, education levels and, in many ways, a common history (Otterlei and Sande 2010), there seems to be national socio-cultural structures that introduce variability to illegal hunting and general environmental attitudes (Gangaas et al. 2013, 2014). One difference between the countries is that Swedes are used to a top-down and Norway a bottom-up governance system (Otterlei and Sande 2010), which result in that Swedes are more likely to accept centralised management decisions (Skogen 2001, Skogen 2003, Skogen and Thrane 2008, Otterlei and Sande 2010).

For several decades, it has been evident that environmental management requires integration of natural and social sciences. Such a multidisciplinary approach is complex as natural resource management always is somehow specified in space. Social sciences, on the other hand, typically operate with concepts that are difficult to define in spatial terms, such as processes and discourses related to institutions, power relations and macro-level socio-economic changes or psychological aspects of human-environment interactions. In addition, except for fear, the spatial scaling of environmental attitudes seems to be more or less disconnected from the ecological processes and rather linked to large scale socio-spatial structures (Treves and Karanth 2003, Bisi et al. 2007, Johansson et al. 2012).

Our approach for estimating the variance components of attitudes and feelings is, however, a way to link the social-ecological systems. For instance, from a purely ecological perspective, recolonisation of carnivores in the Scandinavian Peninsula would benefit from a joint Swedish-Norwegian management model. However, the potential for conflicts increases with increasing variation in attitudes (Manfredo et al. 2003, Vaske et al. 2010). If management increases its management units towards the scale of highest attitudinal variance components, it runs the danger of increasing environmental and social conflicts. In ecological terms, while it might be preferable to establish a common Scandinavian management model for large carnivores, the results from this study suggest that differences between the countries in socio-cultural traditions and attitudes linked to the carnivore situation might fuel increased societal conflicts. Another example would be that attempts to reduce fear of carnivores should direct attention to specific and local issues and recognise fear as a legitimate response to changing environments. Finally, attempts to influence environmental attitudes or value orientations correspond better to national level management policies.

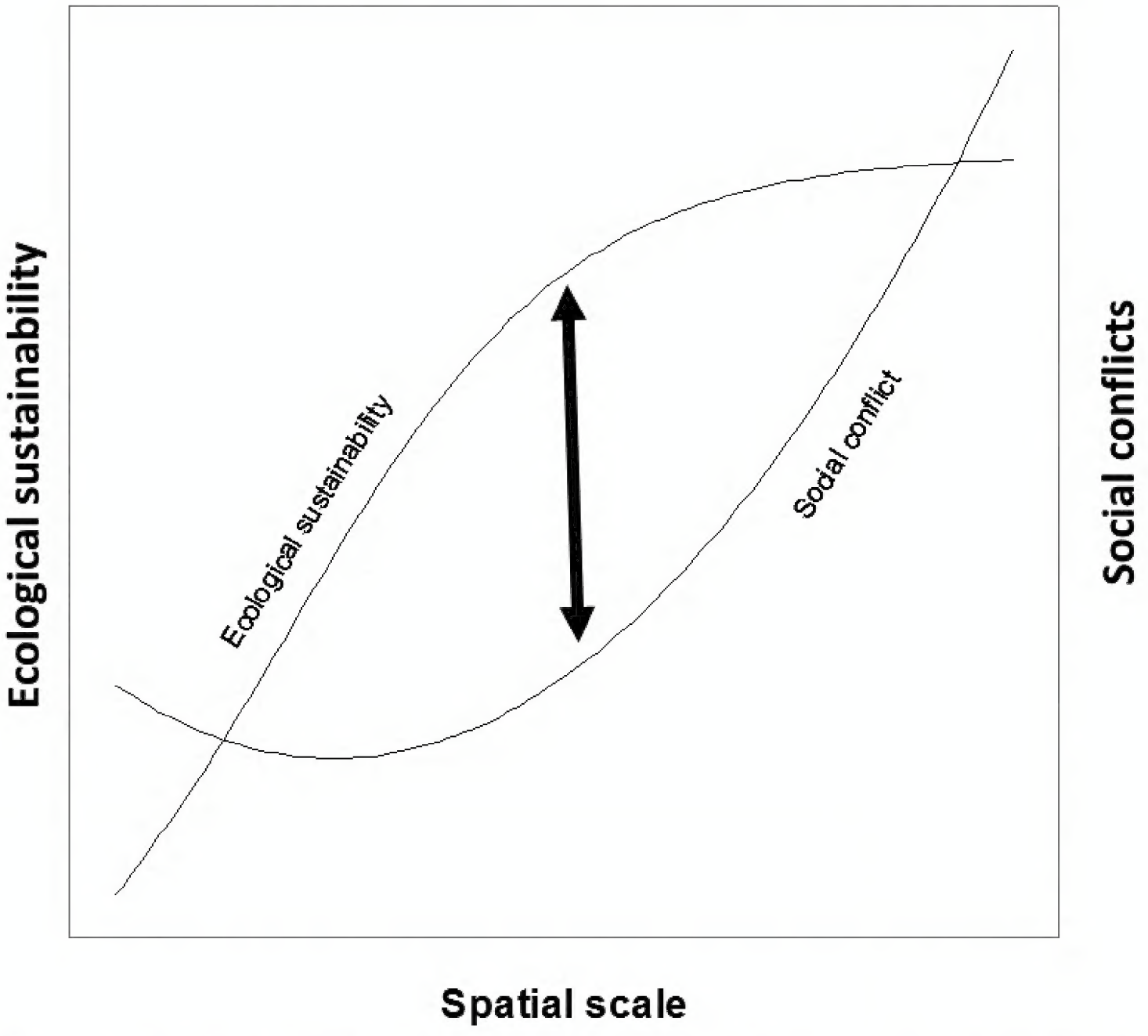

Figure 4. A conceptual model describing how spatial scale described as the extension of an area depends on the trade-off between ecological sustainability and social conflicts. Environmental management authorities should manage as large units as possible to maintain ecological sustainability, but at the same time keeping low conflict levels, here shown by the arrow.

Conclusion

In Figure 4, we have tentatively depicted the challenge related to these two disciplinary scales. Ecological sustainability requires as large areas as possible. Hence, as spatial scale increases, the ecological sustainability of a system will increase asymptotically. Social conflicts due to varying attitudes may be lowest at some kind of intermediate scale (e.g. municipality or county) and highest at large scales (international scales), while some social conflicts may also appear at local scales. Conservation policies need to design management units as the best possible trade-off between the social and ecological scales, by increasing management units to maintain sustainable ecological systems, while maintaining the lowest possible degree of social conflicts.

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